DESCRIPTION

A TUBE PUMMP

Technical Field

The present invention is related to a tube pump that transfers a fluid by deforming a tube elastically.

Background Art

As one example of a tube pump for transferring a fluid by deforming a tube elastically, a tube pump, which includes a casing of which a part of an inner wall surface is formed like a circular arc surface, an elastic tube provided along the circular arc surface of the casing, and a roller pivotably provided on a circular orbit along the circular arc surface in the casing for pressure-feeding the fluid in the elastic tube by pushing the elastic tube toward the circular arc surface on the circular orbit corresponding to the circular arc surface, is known (for example, see Japanese Laid-Open Patent Application No. Hei. 8-28453).

However, there is a problem that the tube pump having such a structure requires a large amount of energy when the elastic tube is squashed by the roller.

Further, as another example of the tube pump, a tube pump for transferring a fluid in which a tube is linearly arranged on an inner surface of a door member attached to a case body so as to be capable of opening and closing, and the fluid is transferred by squashing the tube at three portions along a longitudinal direction thereof with pushing means sequentially is known (for example, see Japanese Laid-Open Patent Application No. Hei. 8-170590).

However, there is still a problem that the tube pump having such a structure also requires a large amount of energy when the elastic tube is squashed.

Moreover, as still another example of the tube pump, a tube pump for pressure-feeding a fluid in a tube in which a motor and support side connecting means are provided on a support so that a rotational shaft of the motor corresponds with a central axis of the support side connecting means, one end and the other end of the tube are respectively connected to the support side connecting means and motor side connecting means provided on the rotational axis of the motor, and the fluid is transferred by giving the tube torsion and untorsion by normal and reverse rotations of the motor (for example, see Japanese Laid-Open Patent Application No. 2002-70748).

However, in the tube pump having such a structure, since it is necessary to rotate the rotational shaft of the motor in normal and reverse directions, this requires an operation to negate inertia of the motor every time the rotational direction of the motor is changed. Thus, there is a problem that energy loss occurs in the operation.

Disclosure of Invention

The present invention is made in consideration of the above-mentioned problems. It is an object of the present invention to provide a tube pump capable of effectively transferring the fluid at a small amount of energy without requiring a large amount of energy, whereby it is possible to reduce a running cost of the tube pump and the energy loss does not occur.

In order to achieve the above-mentioned object, the present invention is directed to a tube pump for transferring a fluid. In one embodiment of the invention, the tube pump includes:

a tube defining a flow path therein through which the fluid is transferred, the tube being capable of being deformed elastically, the tube having two opening/closing portions provided at two spaced portions of the tube for opening and closing the flow path; and

two opening/closing mechanisms which are provided so as to

correspond to the two opening/closing portions respectively for closing the flow path at the two spaced portions of the tube by folding the corresponding opening/closing portion of the tube and opening the flow path by unfolding the fold of the opening/closing portion;

wherein, when one of the two opening/closing portions is further folded after closing the flow path at the corresponding portion of the tube by operating the corresponding opening/closing mechanism in a state where the other opening/closing portion is folded, an internal pressure in the tube between the two opening/closing portions is increased due to the further fold of the opening/closing portion, and the tube pump transfers the fluid using the increased internal pressure in the tube.

According to the invention, it is sufficient to merely carry out the fold and unfold of each of the opening/closing portions by the opening/closing mechanisms when the fluid is transferred. Hence, it is possible to effectively transfer the fluid at a small amount of energy, and therefore to save the energy, whereby it is possible to reduce a running cost thereof.

In the tube pump of the invention, it is preferable that the degree of the fold of the tube at the one opening/closing portion is different from that at the other opening/closing portion to generate the increased internal pressure.

In the tube pump of the invention, it is preferable that the tube has two spaced curved portions, and each of the two opening/closing portions is provided at a part of each of the two curved portions; and that the tube pump is constructed so that each of the two opening/closing portions is folded by pushing the part of each of the two curved portions with the corresponding opening/closing mechanism.

According to the invention, it is sufficient to merely carry out pushing each of the curved portions and releasing the pushing state of the curved portion when the fluid is transferred. Hence,

it is possible to effectively transfer the fluid at a small amount of energy, and therefore to save the energy, whereby it is possible to reduce a running cost thereof.

In the tube pump of the invention, it is preferable that each of the opening/closing mechanisms includes a cam rotatably provided at a position where the cam faces to the corresponding curved portion, in which each of the two opening/closing portions is folded or unfolded by rotationally driving the corresponding cam so as to push the corresponding curved portion or to release the pushing state by the cam.

According to the invention, when the cam is rotatively driven, the opening/closing portion is folded by pushing a part of the curved portion by the rotative driving of the cam to close the flow path corresponding to the opening/closing portion, and the opening/closing portion is restored to the original shape thereof from the folded state by releasing the pushing state to open the flow path corresponding to the opening/closing portion.

Therefore, it is sufficient to merely carry out pushing each of the curved portions with the cam and releasing the pushing state of the curved portion when the fluid is transferred. Hence, it is possible to effectively transfer the fluid at a small amount of energy, and therefore to save the energy, whereby it is possible to reduce a running cost thereof dramatically. Further, it is sufficient to rotatively drive the cam in one direction, the energy loss does not occur, whereby it is possible to transfer the fluid effectively.

In the tube pump of the invention, it is preferable that the degree of fold of the tube at the one opening/closing portion is differentiated from that at the other opening/closing portion by differentiating sizes of the two cams each other.

According to the invention, since the sizes of the cams are different from each other, it is possible to surely generate a

difference in size of the degrees of fold of the opening/closing portions when the opening/closing portions are folded by rotatively driving the cam.

Further, it is sufficient to merely carry out pushing each of the curved portions with the two cams (large and small cams) and releasing the pushing state of the curved portion when the fluid is transferred. Hence, it is possible to effectively transfer the fluid at a small amount of energy, and therefore to save the energy, whereby it is possible to reduce a running cost thereof dramatically. Moreover, it is sufficient to rotatively drive the cam in one direction, the energy loss does not occur, whereby it is possible to transfer the fluid effectively.

In the tube pump of the invention, it is preferable that each of the two cams has a substantially semicircular shape.

Further, in the tube pump of the invention, it is preferable that each of the opening/closing mechanisms further includes a protective frame reciprocatively provided so as to push the part of the corresponding curved portion or release the pushing state of the part, the protective frame being reciprocatively movable by rotationally driving the cam provided inside the frame; and that the tube pump is constructed so that, while each of the two cams is rotatively driven, the corresponding opening/closing portion is folded by pushing the part of the curved portion by movement of the protective frame toward the tube, and the opening/closing portion is restored to an initial state thereof by elastic force of the tube itself when the pushing state by the protective frame is released so as to move the protective frame toward the opposite direction.

According to the invention, the opening/closing portion is folded by pushing the part of the curved portion by movement of the protective frame toward the tube when the cam is rotatively driven, and the opening/closing portion is restored to the initial shape (original shape) thereof by elastic force of the tube itself

when the pushing state by the protective frame is released so as to move the protective frame toward the opposite direction.

Therefore, since the driving force of the cam can be transmitted to the curved portion without transmission loss, it is possible to carry out the fold of the opening/closing portion of the curved portion and the restoration of the fold effectively.

In the tube pump of the invention, it is preferable that each of the opening/closing mechanisms further includes a connector for connecting the protective frame to the opening/closing portion.

According to the invention, since the protective frame is connected to the opening/closing portion with the connector, the opening/closing portion is not worn down due to slipping between the opening/closing portion and the protective frame. Therefore, it is possible to obtain a stable performance for a long time.

It is preferable that the tube pump of the invention further includes a base for supporting the tube so that each of the two curved portions can be deformed elastically, and for supporting the two protective frames so that each of the two protective frames is reciprocatively moved in the base.

According to the invention, since the tube and the protective frame are supported to the base, the opening/closing portion can be always folded at a predetermined position. Hence, it is possible to transfer the fluid at a predetermined constant amount, and this makes it possible to improve transmission efficiency of the tube pump.

In the tube pump of the invention, it is preferable that each of the opening/closing mechanisms further includes biasing means arranged between the protective frame and the base for biasing the protective frame in the opposite direction, wherein the protective frame moves in the opposite direction by

combination of restoring force of the opening/closing portion and biasing force of the biasing means when the pushing state by the protective frame is released.

According to the invention, even in the case where the elastic force of the tube weakens due to aged deterioration, it is possible to restore the folded portion of the tube to the original shape using the biasing force of the biasing means, and this makes it possible to obtain a sufficient performance of the tube pump for a long time.

It is preferable that the tube pump of the invention further includes a fixing jig for fixing a predetermined portion of the tube to the base, wherein the tube pump is constructed so that the degree of fold of each opening/closing portion can be controlled by adjusting a mounting position of the fixing jig with respect to the base.

According to the invention, since it is possible to adjust the degree of fold of the opening/closing portion of each of the curved portions of the tube using the adjusting means, it is possible to adjust a flow rate of the fluid (traffic volume) without changing the driving speed of the tube pump, and this makes it possible to enhance versatility of the tube pump.

Moreover, it is preferable that the tube pump of the invention further includes adjusting means for adjusting the degree of fold of each of the two opening/closing portions.

Further, in the tube pump of the invention, it is preferable that the flow path is always closed at any one of the two opening/closing portions.

In another embodiment of the invention, a tube pump for transferring a fluid includes:

a tube defining a flow path therein through which the fluid is transferred, the tube being capable of being deformed

elastically, the tube having two opening/closing portions provided at two spaced portions of the tube for opening and closing the flow path, and the two opening/closing portions being arranged so as to face to each other through a predetermined space therebetween; and

an opening/closing mechanism provided in the space between the two opening/closing portions for closing the flow path at the portion corresponding to each of the two opening/closing portions by folding the tube at the opening/closing portion and for opening the flow path by unfolding the fold of the opening/closing portion;

wherein, when one of the two opening/closing portions is further folded after closing the flow path at the corresponding portion of the tube by operating the opening/closing mechanism in a state where the other opening/closing portion is folded, the degree of fold of one opening/closing portion becomes differentiated from that of the other opening/closing portion so that an internal pressure of the tube between the two opening/closing portions is increased due to the further fold of the opening/closing portion, and the tube pump transfers the fluid using the increased internal pressure of the tube.

According to the invention, it is sufficient to merely carry out the fold and unfold of each of the opening/closing portions by the opening/closing mechanisms when the fluid is transferred. Hence, it is possible to effectively transfer the fluid at a small amount of energy, and therefore to save the energy, whereby it is possible to reduce a running cost thereof.

Further, since it is sufficient to provide only one opening/closing mechanism between the two opening/closing portions, it is possible to make the entire tube pump smaller and lighter, and this makes it possible to utilize the tube pump effectively even at a space required so as to make the tube pump smaller and lighter.

In the tube pump of the invention, it is preferable that the tube has two spaced curved portions, and each of the two

opening/closing portions is provided at a part of each of the two curved portions; and that the tube pump is constructed so that each of the two opening/closing portions is folded by pushing the part of each of the two curved portions with the opening/closing mechanism.

According to the invention, since it is sufficient to provide only one opening/closing mechanism between the two opening/closing portions of the tube, it is possible to make the entire tube pump smaller and lighter, and this makes it possible to utilize the tube pump effectively even at a space required so as to make the tube pump smaller and lighter.

In the tube pump of the invention, it is preferable that the opening/closing mechanism comprises a stepped cam in which two cam portions having different sizes are provided in a stepwise manner so that they are rotatable together, an actuator and two arms, and the cam portions respectively have cam surfaces on outer peripheral surfaces thereof; and that the tube pump is constructed so that the two opening/closing portions are respectively brought into contact with the cam surfaces of the stepped cam via the two arms, so that each of the two opening/closing portions is folded or unfolded by each of the two arms while the stepped cam is rotatively driven.

According to the invention, since the two cam portions having different sizes are provided in the stepped cam in a stepwise manner and the opening/closing portions respectively abut on the cam surfaces of the cam portions, it is possible to make the entire tube pump smaller and lighter, and this makes it possible to utilize the tube pump effectively even at a space required so as to make the tube pump smaller and lighter.

In the tube pump of the invention, it is preferable that each of the two cam portions of the stepped cam has a substantially semicircular shape.

Further, in the tube pump of the invention, it is preferable that the opening/closing mechanism further includes biasing means for biasing each of the arms in a direction that the fold of the opening/closing portions is released.

According to the invention, even in the case where the elastic force of the tube weakens due to aged deterioration, it is possible to restore the folded portion of the tube to the original shape using the biasing force of the biasing means, and this makes it possible to obtain a sufficient performance of the tube pump for a long time.

It is preferable that the tube pump of the invention further includes adjusting means for adjusting the degree of fold of each of the two opening/closing portions.

According to the invention, since the degree of fold of the opening/closing portion of the tube can be adjusted by the adjusting means, it is possible to adjust a flow rate of the fluid (traffic volume) without changing the driving speed of the tube pump, and this makes it possible to enhance versatility of the tube pump.

In the tube pump of the invention, it is preferable that the flow path is always closed at any one of the two opening/closing portions.

In still another embodiment of the invention, a tube pump for transferring a fluid includes:

a tube defining a flow path therein through which the fluid is transferred, the tube being capable of being deformed elastically, the tube having two opening/closing portions provided at two spaced portions of the tube for opening and closing the flow path; and

two opening/closing mechanisms which are respectively provided so as to correspond to the two opening/closing portions, one of the opening/closing mechanisms closing the flow path at

one of the two spaced portions of the tube by folding the corresponding opening/closing portion of the tube and opening the flow path by unfolding the fold of the opening/closing portion, and the other opening/closing mechanism closing and opening the flow path at the other portion of the tube without folding and unfolding the corresponding opening/closing portion of the tube;

wherein, when the opening/closing portion is further folded after closing the flow path at the corresponding portion of the tube by operating the corresponding opening/closing mechanism in a state where the other opening/closing portion is closed, an internal pressure in the tube between the two opening/closing portions is increased due to the further fold of the opening/closing portion, and the tube pump transfers the fluid using the increased internal pressure in the tube.

In the tube pump of the invention, it is preferable that the other opening/closing mechanism includes a shut-off valve.

Brief Description of Drawings

The above and other objects, features, and the advantages of the invention will readily become more apparent from the following detailed description of preferred embodiments of the invention with reference to the accompanying drawings.

Fig. 1 is a perspective view showing a tube pump in a first embodiment according to the present invention.

Fig. 2 is a front view of the tube pump shown in Fig. 1.

Fig. 3 is a partially enlarged cross sectional view showing a modified example of the first embodiment.

Fig. 4 is a schematic view showing the operation of the tube pump of the present invention.

Fig. 5 is an explanatory drawing showing an internal pressure between two folded portions of the tube pump according to the present invention.

Fig. 6 is a plan view showing the tube pump in a second embodiment according to the present invention.

Fig. 7 is a plan view showing a tube pump in a third embodiment

according to the present invention.

Fig. 8 is a perspective view showing a cam of the tube pump of the third embodiment.

Fig. 9 is a perspective view showing an arm of the tube pump of the third embodiment.

Best Mode for Carrying Out the Invention

The preferred embodiments of a tube pump of the present invention are described in detail below with reference to the appended drawings.

(First Embodiment)

Fig. 1 is a perspective view showing a tube pump in a first embodiment according to the present invention. Fig. 2 is a front view of the tube pump shown in Fig. 1.

As shown in these drawings, a tube pump 1 of the invention includes: a elastically deformable tube 2 made from elastic element which defines a flow path (not shown) therein through which a fluid (such as various types of gases, various types of liquid or the like) is transferred; two opening/closing mechanisms 11 which close a part of the flow path by folding a part of the tube 2 and open the part of the flow path by releasing (unfolding) the fold of the part of the tube 2; and a base 31 that supports the tube 2 and the opening/closing mechanisms 11.

The tube 2 has a feature that the tube 2 can be bent (or folded) easily by receiving outer force (load) in a direction substantially perpendicular to a longitudinal direction of the tube 2, and be restored to an initial state (initial shape) thereof from a folded (bent) state by removing the outer force (load). The part of the flow path is closed or opened by folding the tube 2 or restoring the folded state of the tube 2.

There is no particular limitation to the construction material of the elastic element constituting the tube 2, and various rubber materials such as silicone rubber, various

thermoplastic elastomers, various synthetic resins, various resin materials and the like may be used, for example.

The tube 2 has two U-shaped (substantially U-shaped) curved portions 3, 6 formed so that a linear tubular member is curved at two points, and therefore the entire tube 2 becomes a substantially M-shaped structure. Further, the entire tube 2 is supported by the base 31 (described later) so that each of the curved portions 3, 6 becomes elastically deformable (i.e., foldable and restorable (unfoldable)).

Two opening/closing portions 4, 7 for opening and closing the flow path are respectively provided at parts of the curved portions 3, 6 of the tube 2. Each of the two opening/closing portions 4, 7 is folded to a predetermined angle (so as to become a predetermined degree of fold) by pushing (applying outer force to) a part of each of the curved portions 3, 6 with each of the opening/closing mechanisms 11 (described later), and restores to an original U shape of each of the curved portions 4, 7 from the folded state by elastic force (self-restoring force) of the tube 2 by releasing the pushing force (outer force).

Each of the two opening/closing portions 4, 7 closes a portion of the flow path corresponding to each opening/closing portion 4, 7 by folding it to prevent the fluid from flowing in the flow path, and opens the portion of the flow path corresponding to each opening/closing portion 4, 7 by releasing the fold thereof (restoring it from the folded state to the original state (original shape)) to allow the fluid to flow in the flow path.

In this embodiment, the two curved portions 3, 6 are provided at both end portions of the tube 2 in the tube pump 1, and each of the two opening/closing portions 4, 7 is provided at a part of each of the curved portions 3, 6. However, although it is not shown in the drawings, three or more curved portions may be provided at three or more portions of the tube 2, and the opening/closing portions may be respectively provided at parts

of the curved portions.

The base 31 has a rectangular shape, and a series of engagement groove 32 for engaging the tube 2 is arranged on a front surface side of the base 31. By engaging almost entire tube 2 except for the both end portions thereof in the engagement groove 32, the tube 2 is supported in the base 31 in combination with the elastic force of the tube 2 itself and frictional force between the tube 2 and the engagement groove 32. Material of the base 31 is not particularly limited, but various synthetic resins are preferable to save weight of the tube pump 1.

Concave portions 33, 34 for the curved portions each having a rectangular shape, of which a dimension is larger than a dimension of each of the curved portions 3, 6, are respectively formed in portions of the engagement groove 32 corresponding to the curved portions 3, 6 of the tube 2. By respectively placing the curved portions 3, 6 of the tube 2 in the concave portions 33, 34, it is possible to fold the opening/closing portions 4, 7 of the curved portions 3, 6 and to restore them from the folded state to the original state.

One end portion 9 of the tube 2 protrudes outside the base 31 from one end of the engagement groove 32, while the other end portion of the tube 2 protrudes outside the base 31 from the other end of the engagement groove 32. These protruding one end portion 9 and the other end portion 10 of the tube 2 are connected to either a supply side (not shown) or discharge side (not shown) of the tube pump 1.

As mentioned above, the tube 2 is fixed in the engagement groove 32 of the base 31 in combination with the elastic force of the tube 2 itself and the frictional force between the tube 2 and the engagement groove 32. However, one or two adjusting means 37 as shown in Fig. 3 may be provided at the one end portion 9 and/or the other end portion 10 of the tube 2 that protrude from the engagement groove 32 (in the case where one adjusting means 37 is

provided, it is preferable that the adjusting means 37 is provided at the one end portion 9 side), and the tube 2 may be thereby fixed in the base 31 by the adjusting means 37. Fig. 3 is a partially enlarged cross sectional view showing a modified example of the first embodiment.

The adjusting means 37 is provided with a tubular fixing jig 38 having a flange portion 39 at one end, a fixing jig side female screw portion 40 provided at a state where the fixing jig side female screw portion 40 passes through the flange portion 39 of the fixing jig 38, a base side female screw portion 41 provided at a portion of the base 31 side corresponding to the fixing jig side female screw portion 40, and an adjusting screw 42 threadably engaged in the fixing jig side female screw portion 40 and the base side female screw portion 41. By mating (engaging) the one end portion 9 or the other end portion 10 of the tube 2 with a central portion of the fixing jig 38, the end portion 9 and/or the other end portion 10 of the tube 2 is fixed to the base 31.

In this case, by turning the adjustment screw 42 of the adjusting means 37, it is possible to adjust a distance between the flange portion 39 of the fixing jig 38 and the base 31. Thus, by tightening or loosening the adjustment screw 42 to push or pull the one end portion 9 or the other end portion 10 of the tube 2 into or from the engagement groove 32 together with a tubular portion of the fixing jig 38, it is possible to adjust the degree of fold (an angle of fold) of each of the opening/closing portions 4, 7 of the curved portions 3, 6 of the tube 2.

This makes it possible to adjust a flow rate of the fluid (traffic volume) without changing the driving speed of the tube pump 1, whereby it is possible to enhance versatility of the tube pump 1.

In this regard, the adjusting means 37 is not limited to the above structure. For example, any structure may be used as long as the tube 2 can be fixed to the base 31 and the degree of

fold of each of the opening/closing portions 4, 7 of the curved portions 3, 6 of the tube 2 can be adjusted.

Rectangular guide grooves 35, 36 each extending obliquely upward from downward corner portions are respectively provided on portions corresponding to corner portions (internally upward) of the concave portions 33, 34 for the curved portion 3, 6 of the base 31. Each of the opening/closing mechanisms 11 (described later) is provided in each of the guide grooves 35, 36.

The guide grooves 35, 36 are provided so that tip portions of the protective frames 12, 12 (described later) respectively abut on the curved portions 3, 6 of the tube 2 from the directions perpendicular to the longitudinal directions of the tube 2 at the curved portions 3, 6. In this embodiment, the guide grooves 35, 36 are provided so that the centerlines thereof are respectively positioned on diagonal lines of the concave portions 33, 34 for the curved portion 3, 6.

The opening/closing mechanisms 11 are respectively provided with two protective frames 12, 12 reciprocatively provided to push the parts of the curved portions 3, 6 (i.e., the opening/closing portions 4, 7) in longitudinal directions of the guide grooves 35, 36, two cams 16, 23 positioned in the protective frames 12, 12 and rotatably supported to the base 31 via bearings or the like (not shown in the drawings), two actuators 21, 28, and two power transmission mechanisms 22, 29 for respectively transmitting driving forces of the actuators 21, 28 to the cams 16, 23.

Each protective frame 12 has a frame-shaped structure and is provided with a front frame portion 13 positioned at the tube 2 side, a back frame portion 14 positioned at the back of the front frame portion 13 by a predetermined distance, and two side frame portions 15, 15 that connects the front frame portion 13 to the back frame portion 14. The protective frames 12, 12 are arranged so that the outer surfaces of the front frame portions 13 respectively abut on the outer surfaces of the curved portions

3, 6 of the tube 2.

The front frame portion 13 of each protective frame 12 and each of the curved portions 3, 6 of the tube 2 are connected to each other via a connector 30 such as a band. Relative slip occurs between the front frame portion 13 of each of the protective frames 12 and each of the curved portions 3, 6 of the tube 2 (that is, the front frame portion 13 of each of the protective frames 12 and each of the curved portions 3, 6 of the tube 2 slip together within the concave portion 33 or 34 for the curved portion 3 or 6) while the protective frames 12 reciprocate, thereby preventing the curved portions 3, 6 from being rubbed with the protective frames 12. In this regard, in the case where the relative slip does not occur between the front frame portion 13 of each of the protective frames 12 and each of the curved portions 3, 6 of the tube 2, it is no need to provide the connector 30 in the tube pump 1.

Each of the cams 16, 23 is a planer cam having a substantially semicircular-shaped structure, and outer peripheral surfaces of the cams 16, 23 are formed on cam surfaces 17, 24, respectively. The cam surfaces 17, 24 are provided with curved surface portions 18, 25 that respectively have semicircular arc shapes so that the centers of rotation 20, 27 of the cams 16, 23 become the centers of the cams 16, 23, and linear flat surface portions 19, 26 each of which connects both ends of each of the curved surface portions 18, 25. Boundary portions between the curved surface portions 18, 25 and the flat surface portions 19, 26 are formed as curved surfaces each having a predetermined curvature (smaller than the curvature of each of the curved surface portions 18, 25). Material of the cams 16, 23 is not particularly limited, but various synthetic resins are preferable to save weight of the tube pump 1.

The actuators 21, 28 are, for example, motors and they are attached to the back face of the base 31. The power transmission mechanisms 22, 29 are respectively provided between driving shafts (not shown) of the motors 21, 28 and the cams 16, 23. Each of the

power transmission mechanisms 22, 29 makes the driving force of each of the motors 21, 28 be transmitted to each of the cams 16, 23, whereby each of the cams 16, 23 is rotatively driven. A motor with a decelerator is effective as the motors 21, 28. Since the motor with the decelerator can be rotated at a low speed, it is possible to obtain high torque; it is no need to provide an additional decelerator to the motor; and the curved portions 3, 6 of the tube 2 can follow the movement of the protective frames 12 when the curved portions 3, 6 are restored to the original shape thereof. In this regard, the actuators 21, 28 are not limited to the motors, and an actuator using electromagnetic force, an actuator using fluid pressure, or the like may be used.

The power transmission mechanisms 22, 29 respectively transmit the driving force of the motors 21, 28 to the cams 16, 23. By rotating the cams 16, 23 in sync with each other, the power transmission mechanisms 22, 29 have a function to adjust phases of the cams 16, 23 so that the cams 16, 23 when the flat surface portions 19, 26 of the cam surfaces 17, 24 face to the tube 2 side are out of phase with each other by 180°. A gear, a belt, a crank or the like may be mentioned as the power transmission mechanisms 22, 29. In this case, the cams 16, 23 may be rotated in sync with each other using a stepping motor, an encoder or the like as the motors 21, 28. Further, by using a single motor, the cams 16, 23 may be rotated in sync with each other via the power transmission mechanisms 22, 29.

Positional relationship between the curved portions 3, 6 of the tube 2, the cams 16, 23, and the protective frames 12, 12 is set (established) so that the cam surfaces 17, 24 (the flat surface portions 19, 26) of the cams 16, 23 respectively abut on the front frame portions 13, 13 of the protective frames 12, 12 with the opening/closing portions 4, 7 of the curved portions 3, 6 of the tube 2 unfolded (i.e., when the opening/closing portions 4, 7 are in the U-shaped state (initial state)).

By setting such a positional relationship, the

opening/closing portions 4, 7 of the curved portions 3, 6 of the tube 2 alternately repeat the folded state and the original state (restored state), thereby alternately repeating close and open of the flow path corresponding to each of the opening/closing portions 4, 7.

In other words, in the case where each of the curved surface portions 18, 25 of the cam surfaces 17, 24 is positioned at the front frame portion 13 of the protective frame 12, the protective frame 12 is moved to the direction of the tube 2 in each of the guide grooves 35, 36, and each of the curved portions 3, 6 of the tube 2 is pushed inward by the front frame portion 13 of the protective frame 12, whereby each of the opening/closing portions 4, 7 of the curved portions 3, 6 is folded into a substantial V shape to close the flow path corresponding to each of the opening/closing portions 4, 7. On the other hand, in the case where each of the flat surface portions 19, 26 of the cam surfaces 17, 24 is positioned at the front frame portion 13 of the protective frame 12, the pushed state of each of the curved portions 3, 6 by the protective frame 12 is released, whereby each of the opening/closing portions 4, 7 of the curved portions 3, 6 is restored from the substantial V shape to the original U shape by the elastic force of the tube 2 (self-restoring force thereof). At this time, the protective frame 12 follows the restoration of each of the curved portions 3, 6 and is moved in each of the guide grooves 35, 36 in a direction that the protective frame 12 is moved away from the tube 2 (in a direction opposite to the direction in which each of the opening/closing portions 4, 7 is pushed), thereby opening the flow path corresponding to each of the opening/closing portions 4, 7. In this case, the flow path is always closed at any one of (at least one of) the opening/closing portions 4, 7.

Both the cams 16 and 23 are formed so that the sizes of the cams 16, 23 are different from each other, which results in the difference between the degree of fold of the opening/closing portion 4 of the curved portion 3 when the curved portion 3 is pushed by

the rotational drive of the large cam 16 and the degree of fold of the opening/closing portion 7 of the curved portion 6 when the curved portion 6 is pushed by the rotational drive of the small cam 23. By generating the difference between the degrees of fold of the opening/closing portions 4, 7, it is possible to generate a volume difference between the pushed portions positioned at both sides of each of the folded portions 5, 8 when the flow path is closed by folding the opening/closing portions 4, 7. In other words, the degree of fold of the opening/closing portion 4 when the curved portion 3 is pushed by the rotational drive of the large cam 16 is larger than the degree of fold of the opening/closing portion 7 when the curved portion 6 is pushed by the rotational drive of the small cam 23. For this reason, the volume of the pushed portion positioned at both sides of the folded portion 5 when the flow path is closed by folding the opening/closing portion 4 is larger than the volume of the pushed portion positioned at both sides of the folded portion 8 when the flow path is closed by folding the opening/closing portion 7.

A cover (not shown) having a same shape and size as those of the base 31 is attached to the front face side of the base 31. The cover prevents the components of the tube 2 and the opening/closing mechanisms 11 from dropping out from the insides of the engagement groove 32 and the guide grooves 35, 36.

One end portion 9 of the tube 2 of the tube pump 1 in this embodiment constructed as described above is connected to a supply side (not shown) for the fluid, while the other end portion 10 of the tube 2 of the tube pump 1 is connected to a discharge side (not shown) for the fluid. When the cams 16, 23 are rotatively driven by operating the motors 21, 28, respectively, the operation (1) through (4) described below is sequentially repeated.

(1) First, at an initial state, the flat surface portion 19 of the cam surface 17 of the large cam 16 is positioned at the front frame portion 13 side of the corresponding protective frame 12, while the curved surface portion 25 of the cam surface 24 of

the small cam 23 is positioned at the front frame portion 13 side of the corresponding protective frame 12. Thus, the curved portion 3 of the tube 2 keeps in the U shape (initial shape) with non-pushed state, and the flow path corresponding to the opening/closing portion 4 of the curved portion 3 is in the open state. On the other hand, the curved portion 6 is pushed by the corresponding protective frame 12 to fold into the V shape, and the flow path corresponding to the opening/closing portion 7 of the curved portion 6 is in the close state.

In this case, since the opening/closing portion 7 of the curved portion 6 is in the folded state, the volume at both sides of the folded portion 8 is decreased in comparison with the volume before the opening/closing portion 7 is folded.

(2) Subsequently, each of the large and small cams 16, 23 is rotated by 90° from the initial state of the state (1) described above, the curved surface portion 18 of the cam surface 17 of the large cam 16 is positioned at the front frame portion 13 side of the protective frame 12. At this state, the curved portion 3 is pushed by the corresponding protective frame 12, and the opening/closing portion 4 is folded into the V shape to close the flow path corresponding to the opening/closing portion 4. In this case, the small cam 23 (opening/closing portion 7) keeps in the above state (1) described above (the close state).

Further, since both the opening/closing portions 4, 7 of the curved portions 3, 6 are in the folded state, the volume at both sides of each of the folded portions 5, 8 is decreased in comparison with the volume before they are folded (that is, before the opening/closing portion 4 of the curved portion 3 is folded after closing the flow path at the folded portion 8 of the tube 2 by folding the curved portion 6). For this reason, the pressure (internal pressure) between the folded portions 5 and 8 of the tube 2 rises more than that before the fold of the opening/closing portion 4, and becomes higher than the pressure at right side of the folded portion 8 in Fig. 2.

(3) Subsequently, each of the large and small cams 16, 23 is further rotated by 90° from the state (2) described above, the flat surface portion 26 of the cam surface 24 of the small cam 23 is positioned at the front frame portion 13 side of the corresponding protective frame 12. At this state, the folded state of the curved portion 6 is released, and the opening/closing portion 7 is restored from the V shape to the original U shape to open the flow path corresponding to the opening/closing portion 7 of the curved portion 6. In this case, the large cam 16 keeps in the state (2) described above (i.e., the close state).

Further, since the opening/closing portion 4 of the curved portion 3 is in the folded state, the volume at both ends of the folded portion 5 is decreased in comparison with the volume before the opening/closing portion 4 is folded.

(4) Subsequently, each of the large and small cams 16, 23 is further rotated by 90° from the state (3) described above, the curved surface portion 25 of the cam surface 24 of the small cam 23 is positioned at the front frame portion 13 of the corresponding protective frame 12. At this state, the curved portion 6 is pushed by the corresponding protective frame 12, and the opening/closing portion 7 is folded into the V shape to close the flow path corresponding to the opening/closing portion 7. In this case, the large cam 16 keeps in the state (2) described above (i.e., the close state).

Further, since both the opening/closing portions 4, 7 of the curved portions 3, 6 are in the folded state, the volume at both sides of each of the folded portions 5, 8 is decreased in comparison with the volume before they are folded (that is, before the opening/closing portion 7 of the curved portion 6 is folded after closing the flow path at the folded portion 5 of the tube 2 by folding the curved portion 3). For this reason, the pressure (internal pressure) between the folded portions 5 and 8 rises more than that before the fold of the opening/closing portion 7, and

becomes higher than the pressure at left side of the folded portion 8 in Fig. 2.

Subsequently, when each of the large and small cams 16, 23 is further rotated by 90° from the state (4) described above, the large and small cams 16, 23 return to the initial state (1), and one cycle (one revolution) of each of the large and small cams 16, 23 is terminated (ended).

In this regard, at the state (2), the pressure between the folded portions 5 and 8 becomes higher than the pressure at the right side of the folded portion 8 in Fig. 2. Hence, when the large and small cams 16, 23 become in the state (3) and the flow path corresponding to the opening/closing portion 7 of the curved portion 6 is opened, the fluid flows toward right side in Fig. 2.

Further, at the state (4), the pressure between the folded portions 5 and 8 becomes higher than the pressure at the left side of the folded portion 5 in Fig. 2. Hence, when the large and small cams 16, 23 become in the state (1) and the flow path corresponding to the opening/closing portion 4 of the curved portion 3 is opened, the fluid flows toward left side in Fig. 2.

In this case, since the degree of fold of the folded portion 5 of the opening/closing portion 4 is larger than the degree of fold of the folded portion 8 of the opening/closing portion 7, the pressure between the folded portions 5 and 8 right before the flow path corresponding to the opening/closing portion 7 of the curved portion 6 is opened is higher than the pressure between the folded portions 5 and 8 right before the flow path corresponding to the opening/closing portion 4 of the curved portion 3 is opened. For this reason, in one cycle of each of the cams 16, 23, the flow rate of fluid that flows toward right side in Fig. 2 is more than the flow rate of fluid that flows toward left side in Fig. 2. This makes it possible to transfer the fluid from one end of the tube 2 (the left side in Fig. 2) toward the

other end of the tube 2 (the right side in Fig. 2).

By repeating the operation (1) through (4) described above, that is, by repeating open/close of the opening/closing portion 4 of the curved portion 3 and open/close of the opening/closing portion 7 of the curved portion 6, the fluid is sequentially (and continuously) transferred from one end of the tube 2 (the left side in Fig. 2) toward the other end of the tube 2 (the right side in Fig. 2).

Next, the operation of the tube pump 1 in the present embodiment will be described with reference to Fig. 4 and the table in Fig. 5.

(Precondition)

(a) Both the internal pressure and external pressure of the tube 2 at the initial state are atmospheric pressure (i.e., 1atm).

(b) Water is filled in a left end of the tube 2 (see Fig. 4), and the left end is thereby sealed by the water. In this regard, both the left side and the right side of the water at the left end in Fig. 4 are opened to atmospheric pressure.

(c) When the opening/closing portions 4, 7 (folded portions 5, 8) of the tube 2 are folded, right and left sides of each of the folded portions 5, 8 first become in the closed (sealed) state. When the opening/closing portions 4, 7 are further folded, the volume in the tube 2 (the volume between the folded portions 5, 8) is further decreased.

(d) The fold of the folded portion 5 by the protective frame 12 corresponding to the large cam 16 makes the tube 2 be decreased more volume than in the case of the fold of the folded portion 8 by the protective frame 12 corresponding to the small cam 23.

(e) Internal volume of the tube 2 between the folded portions

5, 8 when the right and left sides of each of the folded portions 5, 8 are in the sealed (closed) state and the volume of the tube 2 is not changed by further folding them (i.e., internal volume of the tube 2 between the folded portions 5, 8 at the moment that the tube 2 is closed (sealed) at both the folded portions 5, 8) is assumed to be a volume c. In this regard, in Fig. 4, it is ignored that a change in the internal volume of the tube 2 from the open state to the state at the moment that the tube 2 is sealed (closed) at both the folded portions 5, 8. Therefore, for ease of explanation, the tube 2 corresponding to the portion between the folded portions 5, 8 at the moment that the tube 2 is closed (sealed) at both the folded portions 5, 8 is shown as a cylindrical shape (columnar shape) in Fig. 4.

(f) The volume of the tube 2 that is decreased while the protective frame 12 corresponding to the large cam 16 further folds the tube 2 to a final state (a further folded state) after the tube 2 is folded from the open state (the initial state) to the sealed (closed) state (that is, after the flow path is closed at the folded portion 5 by folding the opening/closing portion 4 of the tube 2) (see Fig. 4) is assumed to be a volume 2 × a. In this case, the substantially same volume a is decreased at both sides of the sealed portion (folded portion 5).

(g) Similarly, the volume of the tube 2 that is decreased while the protective frame 12 corresponding to the small cam 23 further folds the tube 2 to a final state (a further folded state) after the tube 2 is folded from the open state (the initial state) to the sealed (closed) state (that is, after the flow path is closed at the folded portion 8 by folding the opening/closing portion 7 of the tube 2) (see Fig. 4) is assumed to be a volume 2 × b. In this case, the substantially same volume b is decreased at both sides of the sealed portion (folded portion 8).

(h) The internal volume of the tube 2 between the opening/closing portion 4 and the water at the state where the protective frame 12 corresponding to the large cam 16 folds the

tube 2 at the folded portion 5 (that is, the opening/closing portion 4 is in the further folded state) is assumed to be a volume d.

(i) It is ideally assumed that the pressure within the tube 2 is inversely proportional to the volume (isothermal compression: $P \times V$ = constant, where P is a pressure, and V is a volume.).

In this regard, the operation (1) through (9') described below corresponds to rows (1) through (9') in the table of Fig. 5, respectively.

(1) At the initial state, the folded portion 5 corresponding to the large cam 16 is in the open state, and the volume (internal volume) between the folded portions 5, 8 corresponding to the cams 16, 23 becomes c - b. In this case, the volume between the folded portion 5 corresponding to the large cam 16 and the water is assumed to be d as the precondition described above. The pressure inside the tube 2 is assumed to be 1atm (initial value).

(2) First, the folded portion 5 corresponding to the large cam 16 becomes in the close state. The volume between the folded portions 5, 8 corresponding to the cams 16, 23 is decreased by the volume a, and it thereby becomes c - a - b. Since the volume between the folded portions 5, 8 is decreased by the volume a, the pressure between the folded portions 5, 8 becomes (c - a) / (c - a - b) obtained by dividing the volume before change by the volume after change. Since the denominator is smaller than the numerator in the above formula for the pressure, this pressure becomes more than 1atm. Further, the volume between the water and the folded portion 5 corresponding to the large cam 16 becomes d - a. The pressure corresponding to this portion becomes d / (d - a) temporarily, and this pressure also becomes more than 1atm.

(2') Since the tube 2 between the folded portions 5, 8 corresponding to the cams 16, 23 is closed at both ends thereof, the volume or pressure thereof does not change. However, the

pressure between the water and the folded portion 5 corresponding to the large cam 16 becomes higher than the pressure at the left side of the water in Fig. 2, and imbalance occurs between the pressures at both sides of the water. Hence, the water is pushed toward the left side in Fig. 2 temporarily. If it is assumed that the surface tension of the water can be neglected and the water is pushed until the internal pressure becomes 1atm same as the external pressure of the tube 2, this volume becomes d again.

(3) The folded portion 8 corresponding to the small cam 23 becomes in the open state, and the volume between the folded portions 5, 8 corresponding to the cams 16, 23 becomes c - a. Since the right side of the tube 2 in Fig. 2 becomes in the open state to the atmosphere, the pressure thereof returns to 1atm.

(4) The folded portion 8 corresponding to the small cam 23 becomes in the close state again. The volume between the folded portions 5, 8 corresponding to the cams 16, 23 becomes c - a - b again, and the pressure thereof becomes (c - a) / (c - a - b) by dividing the volume before change by the volume after change.

(5) The folded portion 5 corresponding to the large cam 16 becomes in the open state again. The space between the folded portions 5, 8 corresponding to the cams 16, 23 is connected to the space between the water and the folded portion 5 corresponding to the large cam 16, and the pressure in these spaces becomes common (the pressures in the spaces are the same). The volumes thereof are respectively increased by a, a at both ends of the folded portion 5. As the precondition described above, the pressure after change becomes a value obtained by dividing the total of the respective (pressures × volumes) before change at the state (4) by the volume after change. A computational formula thereof is as follows.

(Pressure before change 1) × (Volume before change 1) + (Pressure before change 2) × (Volume before change 2) = (Pressure after change) × (Volume after change)

(Pressure after change) = {(Pressure before change 1) × (Volume before change 1) + (Pressure before change 2) × (Volume before change 2)} / (Volume after change)

Therefore,
$P = \{(c - a - b) \times (c - a) / (c - a - b) + d \times 1\} / \{(c - b) + (d + a)\} = (c - a + d) / (c - b + d + a)$

Since the denominator is larger than the numerator in the formula for the pressure after change, the pressure after change becomes less than 1atm.

(5') Similar to the operation (2') described above, a pressure difference between both ends of the water occurs. At this time, the pressure at the right side of the water in Fig. 2 is smaller than the pressure at the left side of the water in Fig. 2 (i.e., atmospheric pressure: 1atm). Hence, the water is pushed toward the right side in Fig. 2, whereby the internal pressure returns to 1atm. A computational formula of the volume after change is as follows.

(Pressure before change) × (Volume before change) = (Pressure after change) × (Volume after change)

(Volume after change) = (Pressure before change) × (Volume before change) / (Pressure after change)

Therefore,
$V = (c - a + d) / (c - b + d + a) \times (c - b + d + a) / 1 = c - a + d$

The volume obtained by subtracting the volume between the folded portions 5, 8 (this volume is constant) from the volume after change becomes as follows.

$(c - a + d) - (c - b) = d - a + b = d - (a - b)$

The operation after the state (6) shows the case where the operation (1) through (5') described above is repeated in a similar manner.

Here, when the states (1), (5'), and (9') in which the cams 16, 23 have a same phase are compared with each other, it can be seen from the table that the volume between the water and the folded portion 5 corresponding to the large cam 16 is decreased by a - b each cycle. In other words, the tube pump 1 forms a pump that can transfer (deliver) a liquid by a difference between the volume changes in the folded portions 5, 8 each cycle toward the side where volume change in one of the folded portions 5, 8 is smaller than that in the other.

In this regard, it seems that an actual compression state is not the isothermal compression used as the precondition described above, but polytropic compression (i.e., PV^n = constant). However, since principle of operation in the polytropic compression differs little from that in the isothermal compression, it does not matter. Further, the above explanation is made on the condition that air or gas is filled in the tube 2, but principle of operation in case of liquid is similar to that in case of gas except for the next point. Namely, in the case where liquid is filled in the tube 2, the liquid is not compressed like the gas in the above operation, but is sucked due to elastic power or restoring power of the tube 2 as the tube 2 is swollen (restored) by the elastic power of the tube 2 itself (self-restoring power of the tube 2).

In the tube pump 1 in this embodiment constructed as described above, the curved portions 3, 6 of the tube 2 are respectively pushed via the protective frames 12 by the rotational drive of the large and small cams 16, 23, and the opening/closing portions 4, 7 of the curved portions 3, 6 are thereby folded. Thus, it is possible to close (seal) the flow path corresponding to each of the opening/closing portions 4, 7 by the fold of each of the

opening/closing portions 4, 7. Further, by releasing the pushing state of the cams 16, 23 via the protective frames 12, the opening/closing portions 4, 7 are restored into the original shape by the restoring force thereof (the elastic force thereof), whereby it is possible to open the flow path corresponding to the opening/closing portions 4, 7. Therefore, it is possible to construct the tube pump 1 without the need for a large amount of energy to open and close the opening/closing portions 4, 7, and this makes it possible to reduce a running cost of the tube pump 1.

Further, since the tube pump 1 merely requires rotating the cams 16, 23 in a same direction, energy loss does not occur as opposed to the case of rotating the cams in both normal and reverse directions, respectively. Therefore, it is possible to provide a high-efficiency tube pump.

In the present invention, in place of a mechanism (constitution) of the downstream opening/closing portion 7 side in which the flow path is closed by folding the opening/closing portion 7 and is opened by releasing (unfolding) the fold of the opening/closing portion 7, for example, a shut-off valve may be provided at the opening/closing portion 7 side, and the tube pump 1 of the invention may be constructed so as to open and close the flow path with the shut-off valve.

(Second Embodiment)

Next, a tube pump in a second embodiment according to the present invention will now be described.

In the description of the tube pump 1 of the second embodiment given below, the focus of the description is on the different points between the first embodiment described above and the second embodiment, and a description of the same parts (components) is omitted.

Fig. 6 is a plan view showing the tube pump 1 in the second embodiment according to the present invention. The tube pump 1 of the second embodiment is provided with two biasing means 45 respectively provided between the back frame portions 14, 14 of the two protective frames 12, 12 and inner surfaces of the guide grooves 35, 36 opposing to the back frame portions 14, 14 which biases the protective frames 12, 12 toward the direction that each protective frame 12 is moved away from the tube 2 (that is, which biases the tube 2 in the direction that the fold of each of the opening/closing portions 4, 7 is released). The other components (parts) of the tube pump 1 of the second embodiment are similar to those of the tube pump 1 shown in the first embodiment described above. When the pushing states by the cams 16, 23 are released, the protective frames 12 are respectively moved to the direction so as to be away from the tube 2 (that is, in the direction perpendicular to the longitudinal direction of each of the protective frames 12) forcibly by the biasing force of the two biasing means 45.

As the biasing means 45, for example, a tensional spring (extension spring), a hydraulic or pneumatic cylinder, or the like may be mentioned. For example, in the case where a contracted spring is used, an installing location of the spring may be changed.

Similar to the tube pump 1 shown in the first embodiment, in the tube pump 1 shown in this embodiment, the curved portions 3, 6 of the tube 2 are pushed via the protective frames 12 by the rotational drive of the large and small cams 16, 23, and the opening/closing portions 4, 7 of the curved portions 3, 6 are folded, whereby it is possible to close (seal) the flow path corresponding to the opening/closing portions 4, 7. Further, by releasing the pushing state of the opening/closing portions 4, 7 via the protective portions 12, the opening/closing portions 4, 7 are restored to the original shape by the elastic force of the opening/closing portions 4, 7 themselves (the elastic force of the tube 2), whereby it is possible to open the flow path corresponding to the opening/closing portions 4, 7. Hence, it is possible to

construct the tube pump 1 without the need for a large amount of energy to open and close the opening/closing portions 4, 7, and this makes it possible to reduce a running cost of the tube pump 1.

Further, since the tube pump 1 merely requires rotating the cams 16, 23 in a same direction, energy loss does not occur as opposed to the case of rotating cams in both normal and reverse directions. Therefore, it is possible to provide a high-efficiency tube pump.

Moreover, in this embodiment, the protective frames 12 are respectively moved to the direction so as to be away from the tube 2 (that is, in the direction perpendicular to the longitudinal direction of each of the protective frames 12) forcibly by the biasing force of the two biasing means 45. Hence, even in the case where the elastic force of the tube 2 weakens due to aged deterioration, it is possible to repeat the fold and restoration of the opening/closing portions 4, 7 of the curved portions 3, 6 of the tube 2 stably, and this makes it possible to obtain a sufficient performance of the tube pump 1 for a long time. In this regard, the connector 30 has a function that the opening/closing portions 4, 7 respectively interlock (is linked to) the protective frames 12 so that the tube 2 can shift from the close state to the open state in the case where the elastic force of the tube 2 weakens due to aged deterioration.

(Third Embodiment)

Next, a tube pump in a third embodiment according to the present invention will now be described.

In the description of the tube pump 1 of the third embodiment given below, the focus of the description is on the different points between the first embodiment described above and the third embodiment, and a description of the same parts (components) is omitted.

Fig. 7 is a plan view showing a tube pump 1 in the third embodiment according to the present invention. Fig. 8 is a perspective view showing a cam 50 of the tube pump 1 of the third embodiment. Fig. 9 is a perspective view showing an arm 59 or 61 of the tube pump 1 of the third embodiment. As shown in these drawings, the tube pump 1 is provided with the curved portions 3, 6 (including the opening/closing portions 4, 7) so that the curved portions 3, 6 face to each other with a predetermined space. Further, the tube pump 1 is provided with a cam 50 rotatably provided between the curved portions 3, 6 (that is, within the space), and arms 59, 61 respectively provided between the cam 50 and the curved portions 3, 6 which convert the rotational motion of the cam 50 into the linear motion of each of the arms 59, 61. The tube pump 1 is constructed so that the opening/closing portions 4, 7 of the curved portions 3, 6 are folded via the arms 59, 61 by the rotational drive of the cam 50, and that the opening/closing portions 4, 7 are restored from the folded state to the original U shape (original state) by the elastic force of the tube 2. The other components of the tube pump 1 of the third embodiment are same as the tube pump 1 shown in the first embodiment described above.

As shown in Fig. 8, the cam 50 is a stepped cam in which a large cam portion 51 and a small cam portion 55 having different sizes (radii) are provided in a stepwise manner so that they are rotatable together. The cam 50 is constructed so that a tip portion of one arm 59 abuts on a cam surface 52 that is an outer peripheral surface of the large cam portion 51, and a tip portion of the other arm 61 abuts on a cam surface 56 that is an outer peripheral surface of the small cam portion 55. Further, as shown in Fig. 9, through-holes 60, 62 passing through the arms 59, 61 in a direction perpendicular to the longitudinal direction of each of the arms 59,61 (axis line thereof) are respectively provided at the tip portions of the arms 59, 61, and the curved portions 3, 6 of the tube 2 are inserted into the through-holes 60, 62 of the arms 59, 61. The arms 59, 61 are placed in guide grooves 66,

67 provided in a base 65 so that the longitudinal direction of each of the arms 59, 61 is parallel to the longitudinal direction of the base 65 (see Fig. 7), whereby they can reciprocate in horizontal directions of the arms 59, 61 (i.e., in a horizontal direction of the base 65).

Similar to the tube pump 1 shown in the first embodiment, in the tube pump 1 shown in this embodiment described above, the curved portions 3, 6 of the tube 2 are pushed via the arms 59, 61 by the rotational drive of the cam 50. By folding each of the opening/closing portions 4, 7 of the curved portions 3, 6, it is possible to close (seal) the flow path corresponding to each of the opening/closing portions 4, 7. Further, by releasing the pushing state of each of the opening/closing portions 4, 7 via the arms 59, 61, the opening/closing portions 4, 7 are restored to the original shape by the elastic force of the opening/closing portions 4, 7 themselves (the elastic force of the tube 2), whereby it is possible to open the flow path corresponding to the opening/closing portions 4, 7. Hence, it is possible to construct the tube pump 1 without the need for a large amount of energy to open and close the opening/closing portions 4, 7, and this makes it possible to reduce a running cost of the tube pump 1.

Further, since the tube pump 1 merely requires rotating the cam 50 in one direction, energy loss does not occur as opposed to the case of rotating a cam in both normal and reverse directions. Therefore, it is possible to provide a high-efficiency tube pump.

Moreover, in this embodiment, since the fold and restoration of the opening/closing portions 4, 7 of the curved portions 3, 6 can be carried out with the single cam 50, it is possible to make the tube pump 1 small-footprint, and to make the entire tube pump 1 smaller and lighter. This makes it possible to utilize the tube pump 1 effectively even at a space required so as to make the tube pump 1 smaller and lighter.

In this regard, similar to the tube pump 1 of the second

embodiment described above, the biasing means 45 may be provided in the tube pump 1 of this embodiment.

The present invention was described above based on the embodiments shown in the drawings, but the present invention is not limited to those embodiments, and the structure of each component (element) can be replaced by any structure capable of performing the same or a similar function. Further, any other components may be added to the present invention.

Further, the present invention may combine any two or more structures (features) from the embodiments described above.

Moreover, three or more opening/closing portions may be provided in the tube pump of the present invention.

This application claims priority to Japanese Patent Application No. 2003-300038 filed August 25, 2003, which is hereby expressly incorporated by reference herein in its entirety.